National Research Council Canada | Conseil national de recherches Canada

NRC · CNRC

Canadian experience in healthy housing

Shaw, C. Y. ; Magee, R. J. ; Swinton, M. C. ; Riley, M. ; Robar, J.

NRCC-44699

A version of this paper is published in / Une version de ce document se trouve dans :

International Symposium on Current Status of Indoor Air Pollution by Organic Compounds and Countermeasures for Healthy Housing, Tokyo, Japan, 2001, pp. 31-35

www.nrc.ca/irc/ircpubs

construction

Institute for Research in Construction | Institut de recherche en construction | IRC

104-03025/

Canadian Experience in Healthy Housing

C. Y. Shaw[1], R.J. Magee[1], M.C. Swinton[1], M. Riley[2], and J.Robar[3]

1. Institute for Research in Construction, National Research Council Canada
2. CANMET Energy Technology Centre, Natural Resources Canada
3. Canada Mortgage and Housing Corporation

Abstract

Canada's efforts in healthy housing are based mainly in various low energy house programs. Since the early 1980s, Natural Resources Canada has launched two major programs to promote the construction of energy efficient or low energy houses (Mayo and Sinha 1996, Sinha 1996). The first one is the R-2000 program that was established in 1982. The performance target for R-2000 houses was based on a 50% reduction in the energy consumption for space and hot water heating compared to houses built to the 1975 National Building Code of Canada. Even though this performance target was focused on energy conservation, some of the measures incorporated in the R-2000 houses to reduce energy use (e.g., increased insulation level, improved whole house airtightness levels, and mechanical ventilation with heat recovery) also resulted in the added benefit of improved indoor air quality. More than 8000 houses have now been certified as R-2000 houses.

In response to the Canadian government's commitment to reduce CO_2 production and global warming, Natural Resources Canada launched the Advanced Houses program in 1991. The Advanced Houses program used the same performance-based standard as for R-2000 houses, but went beyond energy efficiency into issues such as selection of environmentally-friendly building materials, indoor air quality, water and waste reduction, recycling, and elimination of CFCs. To stimulate interest, a competition was organized to challenge the building industry to build houses that were twice as energy efficient and twice as "green" as the best R-2000 houses currently on the market. Of the thirty-one teams entered the competition, ten winning proposals were selected, and the construction of these houses was completed in 1993. Figure 1 compares the purchased energy for R-2000, Advanced and conventional houses. As shown the values of the total purchased energy were normalized for house size including basement and for climate, in terms of floor area and heating degree-days, respectively. In Figure 1, R-2000 (1983-1986) and R-2000 (1986-1988) refer to the measurements conducted on houses built from 1983 to 1986 and from 1986 to 1988, respectively. The 1975 Code and 1983 measurements refer to conventional houses built to the specifications recommended by the 1975 National Building Code and 1983 insulation levels in most new houses. The 1983 measured result is a good indicator of conventional houses built today.

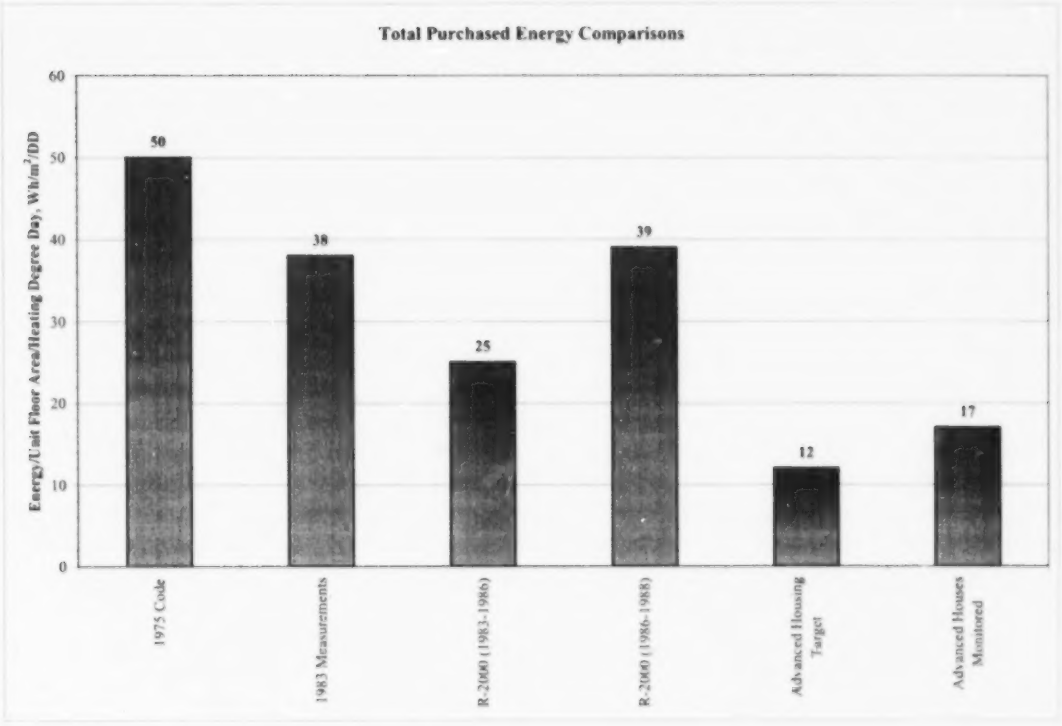

Figure 1, Total purchased energy for conventional houses and low energy houses

In addition to their energy efficiency, R-2000 and Advanced houses are distinguished from conventional houses by their superior whole house airtightness, mechanical ventilation systems with heat recovery, and supply air outlets in each room.

During the past ten years, Canada Mortgage and Housing Corporation (CMHC) has launched several healthy housing initiatives for both the environmentally hypersensitive (EH) and the general public. These initiatives have identified many practical and viable options that can be incorporated into houses to improve air quality. One CMHC study reports that the most frequently used features in houses occupied by families with EH members include all-ceramic or hardwood floors, all-electric heating, custom cabinets, ventilation with air filtration systems, and plaster or solid wood interior finishes. In house renovations to accommodate EH family members, the most commonly applied remedial measures are replacing the heating system, changing the flooring, installing air cleaners, replacing cabinets and furniture, and installing a central ventilation system with a heat recovery ventilator.

These various programs are all aimed at improving the overall quality of Canadian homes, including indoor air quality. This paper presents the ventilation and indoor air quality requirements of the Canadian healthy (low energy) houses. The measured ventilation rates and

indicators of indoor air quality for healthy (low energy) houses are compared with those measured in conventional houses and in a house specially designed and constructed for a family with environmentally hypersensitive members.

Also reported, is a brief description of a recently constructed healthy (low energy) house, and its ventilation rates as well as VOC profiles monitored during a period of nine months after the closure of the house envelope. This house is one of three houses built by a local builder based on one of its best selling models, which has been modified to incorporate extra features necessary for meeting R-2000 specifications. These features related to indoor air quality are listed below:

- Low emission carpet carrying the Canadian Carpet Institute's Green Label. The total carpeted area is less than 50% of the total floor area including the basement.
- Medium efficiency pleated air filter with minimum 10% ASHRAE average dust spot test.
- Water-based paints and varnishes, and flooring adhesives.
- Pre-finished wood flooring.
- Linoleum or vinyl floor tiles.
- Kitchen and bathroom cabinets with solid wood doors. All hidden and exposed surfaces of the particle boards used to make these cabinets were sealed with approved low-emission sealer.
- Floor sheathing and underlayment were sealed on all exposed surfaces with approved sealer. Floor sheathing used only phenol-based resins.
- The overall airtightness value was measured to be less than 1.5 ac/h at 50 Pa.
- Central air distribution system with a heat recovery ventilator (HRV) and an electronic air cleaner.
- The ventilation system is capable of providing a continuous supply of ventilation air based on a design airflow rate of 5 L/s to each habitable room, including bathrooms, kitchen and utility rooms, and 10 L/s to master bedrooms and the unfinished portion of the basement. For exhaust systems operating intermittently, the exhaust rates are 50 L/s and 25 L/s for the kitchen and each bathroom, respectively. For continuously operating, the exhaust rates can be reduced to 30 L/s for the kitchen and 15 L/s for each bathroom.

A summary of the results is given below:

The mean air change rate for low energy houses is greater than that for conventional houses. The difference is much more pronounced during the shoulder seasons when the wind and stack effects are minimal.

Figure 2 shows the average TVOC concentrations in R-2000, Advanced, and conventional houses. Also shown, are the TVOC levels of two reference houses, R1 and R2. House R1 is a standard two-storey house. It was tested before in a Canada-wide study of air-tightness involving 195 houses. Based on that study, it was concluded that the measured ventilation condition was similar to that in most tract-built houses of a similar age. House R2 was designed, built and furnished with both low-emission materials and a ventilation system to minimize indoor air pollution. It has successfully provided an acceptable indoor environment for several family members who suffer from asthma and environmental hypersensitivity.

The results indicate that Advanced houses, on average, have lower TVOC levels than R-2000 and conventional houses. It should be pointed out that the results of the Advanced houses are based on unoccupied conditions whereas other houses are based on occupied conditions. It is expected that under occupied conditions, the TVOC level in Advanced and R-2000 houses would be similar. For comparison, Figure 2 shows that the TVOC level in House R2 is higher than both the conventional and low energy houses but is much lower than House R1.

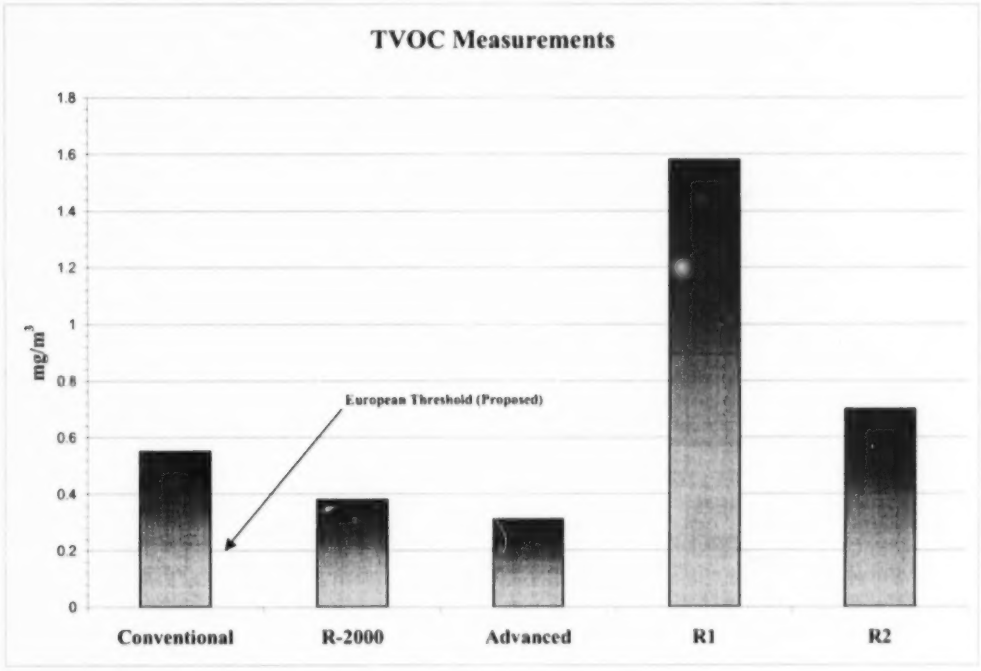

Figure 2 Comparison of TVOC levels

The mean formaldehyde levels in Advanced, R-2000 and conventional houses are not very much different from each other. House R2 has the lowest formaldehyde level. This suggests that it is possible to reduce the formaldehyde levels in houses by selecting appropriate materials.

The monitoring results of a newly constructed healthy (R-2000) house indicate that

- The average air change rate was 0.23 ac/h with the HRV operating at low speed.
- TVOC concentrations were highest during the first week after closure, then decreased with time, becoming relatively stable about 40 days after the house closure at approximately one quarter of the maximum observed level.
- Levels of compounds such as *nonane, dodecane, 1,2,4-trimethylbenzene, limonene, hexanal,* and *methyl ethyl ketone* or *"MEK"* generally showed a slight decrease after about 40 days.
- The concentrations of *1,4-dichlorobenzene, styrene,* and *4-PC* typically did not change significantly during the entire monitoring period.

- The concentration of formaldehyde exceeded Health Canada's Target Level of 60 $\mu g/m^3$ (Health Canada 1995) for most of the monitoring period. It also exceeded the Action Level (120 $\mu g/m^3$) during the entire first week after closure of the house and on two additional occasions during the first 30 days.

References

Haysom, J.C., Reardon, J.T. and Monsour, R., 1990. Survey of Airtightness of New, Merchant Builder Houses, Proceedings, Indoor Air '90, Vol. 4, pp.263-268, Toronto, Canada

Mayo, T. and Sinha, R. 1996. Advanced Houses: Preliminary performance results, End-Use Technology Conference, CEA Electricity 96, Montreal, Canada.

Riley, M. 1986. Ventilation and air quality monitoring in R-2000 houses: measurements and analysis, Report prepared for the R-2000 program, Energy, Mines, and Resources Canada.

Shaw, C.Y., Salares, V., Magee, R.J. 1999. Indoor air quality levels in homes of environmentally hypersensitive individuals. In, Proceedings, Indoor Air 99, The 8th International Conference on Indoor Air Quality and Climate, Aug. 8-13, 1999, Edinburgh, Scotland.
Sinha, R. 1996. Monitoring results from the Advanced houses, the 3rd Canada/Japan Housing R&D Workshop, Ottawa, Canada.